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Up-and-down plowing increases draft of tools, invites soil losses. A year after this picture, the same Missouri farmer, disking over-the-hill with a tractor, found he must keep to low gear. He experimented with a horizontal route, discovered no need to shift from "high." Convinced of the advantages of contour operations, he has since farmed strictly on the level.

A Time Study of Contouring and Straight Farming

By Kenneth P. Zunkel[1]

EARLY in the history of the Big Creek demonstration project at Bethany, Mo., farmers objected to contouring, contour strip cropping, and contouring with terraces. They insisted that these practices would require too much time for farming operations, and in those days the technical men had no data with which to overcome their objections. To meet this deficiency, a time survey was made (in 1935–37) to measure the amount of time required to perform identical operations on contoured, contour-terraced, and straight-farmed fields, using implements of uniform size in all cases. It was realized that there would be many factors to consider—degree of slope, soil type, length of rows, machinery size and power, and the operator himself, whose degree of efficiency might affect the amount of time it took to perform a particular operation on any field. It proved impossible, how-

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Table 1.—*Time required per acre for farming a straight-farmed and a contour-terraced field of corn*

Operation	Tool used	Straight-unterraced field, 10 acres, 6-percent rough slope. Average length of rows, 40 rods			Contour-terraced field, 5 acres, 4-percent gentle slope. Average length of rows, 30 rods		
		Man time	Horse time	Tractor time	Man time	Horse time	Tractor time
		Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.
Plowing	14″ gang	1 30	.....	1 30	1 12	.....	1 12
Disking	7′ tandem	30	.....	30	30	.....	30
Disking	7′ tandem	.....	.....	.....	30	.....	30
Planting	2-row, 2-horse	1 00	2 00	.....	1 12	2 24	.....
Harrowing [1]	8′, 2-horse	30	1 00	.....	.....	.....	.....
Rotary hoeing	2-row, 3-horse	48	2 24	.....	48	2 24	.....
First cultivating	1-row, riding	1 48	3 36	.....	2 00	4 00	.....
Total time required per acre (harrowing omitted) [1]	.....	5 36	8 00	2 00	6 12	8 48	2 12

[1] The harrowing was not included in totals which compare identical field operations. It was necessary because of erosion, and was done for the purpose of filling small trickle gullies not found in the terraced field.

ever, to measure the effects of relationships of all these factors, and in the end the information obtained was analyzed according to the size of machinery used.

In the survey, records were taken on 87 straight-farmed fields with a total of 1,216 acres, on 82 contour-farmed fields with a total of 1,010 acres, and on 33 terraced fields with a total of 383 acres. A man-time rating and a power-time rating were given to the three different methods of farming according to the length of time required for each particular operation. A summary of the records showed very little difference in the man-time rating between heavy-draft machinery (plowing and disking) and light-draft machinery (harrowing, planting, and cultivating). The average horsepower used in heavy-draft operations was 3.3 on straight-farmed fields, 3.2 on contoured fields, and 3.2 on terraced fields. The average horsepower used in light-draft operations was 2.4 on straight fields, 2.3 on contoured fields, and 2.3 on terraced fields.

A tabulation of the samples of data, based on the kind of operation and size of machinery used, and also based only on the kind of operation disregarding the size of the machinery used, indicates that in most cases straight farming required the least amount of time per acre, contour farming more time, and contour farming with terraces the longest time per acre.

Of all the factors mentioned (size of machinery, degree of slope, heavy or light-draft machinery, length of rows, and average unit of power used) no one factor seemed to be outstanding as causing the difference in amount of time required for a given operation. Perhaps a bigger factor than any of these was the newness of the method to the operator. As yet, no way has been found to measure this factor under actual farming conditions.

The following comparisons were taken from four fields on the same farm in the watershed. The two fields in each comparison were as nearly equal as any fields that could be found. The operator never had seen any contour farming until 1934 and was in doubt as to the practicability of the new methods but was willing to try them. The records covered the first year of his experience with contour farming, and by the end of the year he was quite enthusiastic about all three phases—contouring, contour strip cropping, and contouring with terraces. In table 1 comparisons are shown between two fields, one a straight-tilled unterraced field of 10 acres and the other a terraced field of 5 acres farmed on the contour. These two fields were farmed by the same individual. The same implements and power were used although the contour terraced field required an extra disking because of wet ground.

The terraced field required 36 minutes more man time, 48 minutes more horse time, and 12 minutes more tractor time for the same operations per acre. Allowing 25 cents per man-hour, 10 cents per horse-hour, and 80 cents per tractor-hour, the additional cost of contour farming with terraces was 39 cents for the same operations but only 16½ cents if the additional harrowing is included.

Table 2 compares the results obtained on the same farm where operations were identical on a contoured strip-cropped field of 9.2 acres and on a 6-acre straight-farmed field.

The time records on these particular fields, with identical operations, showed that it required 1 hour 25 minutes less man time, 3 hours 54 minutes less horse time, and 6 minutes less tractor time per acre on the contour strip-cropped field.

Using the same rates for man, horse, and tractor time as in discussing table 1, the difference in cost would mean a saving of 82 cents per acre for contouring under these particular conditions. If the additional harrowing of the straight-farmed field is included, the additional cost rises to $1.05 when farming straight.

It will be noticed that in both tables an additional harrowing was necessary, on the straight-farmed fields,

Table 2.—*Time required per acre for farming a straight and a contour strip-cropped field of corn*

Operation	Tool used	Straight-unterraced field, 6 acres, 5-percent uniform slope. Average length of rows 80 rods			Contour strip-cropped field, 9.2 acres, 3-percent uniform slope. Average length of rows 90 rods		
		Man time	Horse time	Tractor time	Man time	Horse time	Tractor time
		Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.
Plowing	14″ gang	1 30	.....	1 30	1 31	.....	1 31
Disking	7′ tandem	40	.....	40	33	.....	33
Harrowing	8′, 4-horse	1 00	4 00	.....	33	2 12	.....
Planting	2-row, 2-horse	1 00	2 00	.....	46	1 32	.....
Harrowing [1]	8′, 2-horse	30	1 00	.....	.....	.....	.....
Rotary hoeing	2-row, 3-horse	1 00	3 00	.....	38	1 54	.....
First cultivating	1-row, riding	2 00	4 00	.....	1 44	3 28	.....
Total time required per acre (harrowing omitted) [1]	.....	7 10	13 00	2 10	5 45	9 06	2 04

[1] The additional harrowing is not included in totals which compare identical field operations. It was necessary because of erosion, and was done for the purpose of filling small trickle gullies not found in the strip-cropped fields.

Table 3.—*Comparison of average time, per acre, of tillage and planting operations for corn, using the mos popular sized machines found in the study*

Operation	Tool used	Straight-farmed		Contoured		Terraced	
		Man time	Horse time	Man time	Horse time	Man time	Horse time
		Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.	Hr. Min.
Plowing	16″	3 40	11 16	3 55	11 58	3 46	11 39
Harrowing	10′	34	1 31	37	1 28	38	1 25
Disking	8′	41	2 38	45	2 26	44	2 35
Planting	2-row	49	1 38	50	1 41	53	1 47
First cultivating	1-row	1 33	3 6	1 37	3 13	1 46	3 31
Second cultivating	do	1 25	2 50	1 25	2 50	1 35	3 10
Third cultivating	do	1 23	2 46	1 17	2 34	1 31	3 2
Total	.....	10 5	25 45	10 26	26 10	10 53	27 9

to fill small trickle gullies not found in the terraced or contour strip-cropped fields. Heavy rains came shortly after planting, in both instances, making the additional harrowing necessary.

While the figures from these particular fields have some value, the comparison of time on a greater number of operations would indicate what is to be expected on the average.

Table 3 gives the amount of time required per acre, with the most popular machines used, and based on the average figures obtained in this study.

While the total time required for these tools appears logical, a few irregularities occurred. A comparison of total figures is similar to that found for other tools in the study but not included in table 3. In comparing contour-with-terrace farming with straight farming, the difference in time was only 48 minutes of man time and 1 hour 24 minutes of horse time for all tillage and planting operations. The difference between the extremes of the three methods of farming was so small as to be negligible in determining which method to use.

THE *Largest* BIG PLOW

By Harry H. Hyatt[1]

SHADES of Paul Bunyan! Nothing like this Gargantuan machine has been seen since that mythical deity of the lumbermen dug the Grand Canyon using his Blue Ox as motive power. This final specimen in a series of plows [2] built by two enterprising southern Californians turns a furrow 6 feet in depth. Other plows in the series turn furrows 2 feet deep and 4 feet deep.

These plows were devised for three purposes: (1) The reclamation of good agricultural land that has been buried under a deposit of sand brought in by flood waters, (2) the elimination of morning glory or other

[1] Section of information, Soil Conservation Service, Santa Paula, Calif.

[2] Turning the Earth Upside Down With a 4-Foot Plow. Soil Conservation, December 1936, p. 123.

Looking Backward Toward the Share. Six-foot Wheels Support the Plow Beam.

noxious weeds by burying them deep enough in the soil to kill them, and (3) the rejuvenation of some of the alluvial and recently deposited soils.

In reclaiming land the plow turns over the sand deposits and fertile soil that has been buried, so that the sand is below and the good soil again in its former position on top. This is accomplished by the plow through an ingenious arrangement. An adjustable blade is mounted on the front of the big plow. This blade scoops the sand down into the gigantic furrow made during the previous passage of the plow. Then, the big plowshare comes along and turns up the old soil on top of the sand.

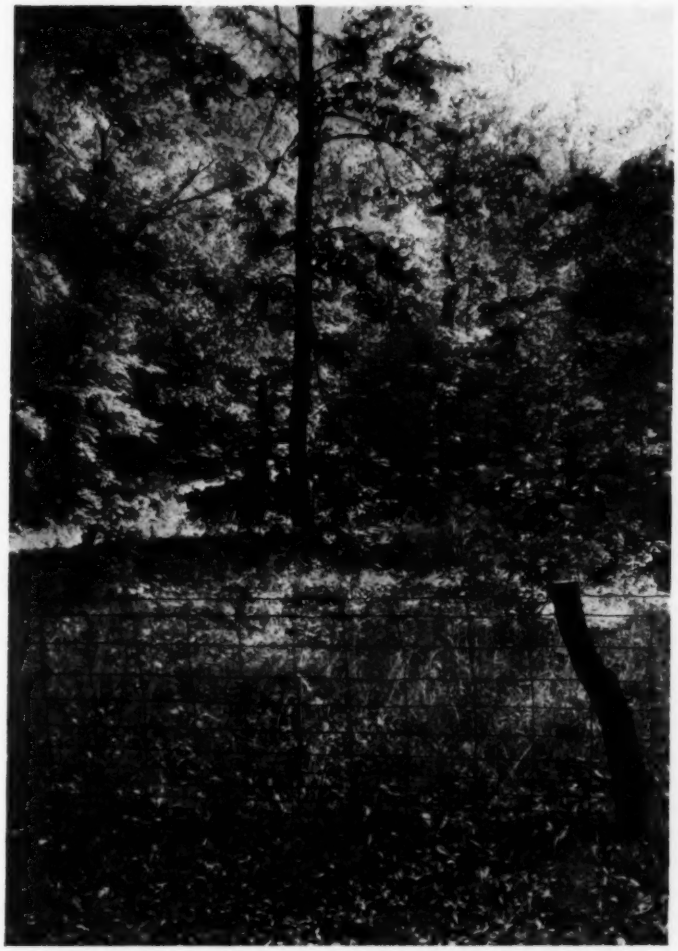
In the rejuvenation of some alluvial soils, it has been found that the plow works satisfactorily where the soils have a uniform and deep profile. Continuous cropping may have exhausted the plant nutrients from the top 1 foot or 18 inches of soil. Turning 2 or 3 feet of this soil upside down brings new and fertile soil to the surface. It must be emphasized that this latter process can be carried on only in certain kinds of soil.

The largest of the plows has two wheels 6 feet in height, is operated by a hydraulic hoist, will bury as much as 4½ feet of sand, and weighs 7 tons. When the going gets tough, it requires five tractors with an aggregate of 400 horsepower to pull it.

About 2,000 acres of land in Orange County, Calif., were deep plowed in 1937; and considering the sand deposits left by the flood of March 2, 1938, that acreage will probably be doubled this year.

This ingenious device is another proof that scientific man can and will keep ahead of adversity.

A Battery of Powerful Tractors Pulls the Knife that Turns Under 4 Feet of Flood-deposited Sand. The Dark Topsoil Comes Out on Top.



Fencing is but One Essential in Intelligent Management.

A Fence Around the Farm Woodland

By John F. Preston[1]

IS IT sufficient from the standpoint of soil conservation to build a fence around the farm woodland which will exclude the grazing of domestic animals? Perhaps we should state the question a little more broadly and ask, is there sufficient justification from the standpoint of erosion control to do more than take the initial steps necessary to protect the farm woodland from fire and grazing? A correct answer to this question is more important now that we are working with farmers in the soil conservation districts than it was when we were purely on a demonstration basis.

To arrive at a correct answer makes it necessary to consider the background of the farm woodland; to consider the basic agricultural philosophy which has been in the minds of farmers and agricultural workers ever since the first settlers cut farms out of the wilder-

[1] Head, section of woodland management, Soil Conservation Service, Washington, D. C.

The Best Removed, Only the Poorest Left—an Application of the "Ground Line" Philosophy. (Photo U. S. Forest Service.)

ness. One has only to review our agricultural literature to realize what is implied in this statement. It is full of such terms as cultivated land and pasture land; crops and livestock; soil-building and soil-depleting crops; clean-tilled crops, small grains, hay, and pasture; and again such terms as cash crops and other crops. By cash crops is meant wheat, corn, cotton, tobacco; and by other crops is usually meant feed for livestock.

It is very rare that analyses of the farm income include any place for recording income from the woods. In the lexicon of most agricultural economists, the words "wood products" are ordinarily not found. All of this is in spite of the fact that more than 15 percent of the total farm area in the United States is in some sort of woods cover; that 25 percent of the farm area east of the Mississippi River is in woodland; and over 40 percent of the area of the average farm in the South and in the Northeast is in woods. All of this in spite of the fact that the 1930 census shows a revenue of 242 million dollars received by the farmers from their woodlands. The amount per farm was, according to the census, $81 in 1909, $217 in 1919, $95 in 1929, and $77 in 1934. Such revenue has come from a neglected, uncared for, untilled, and unappreciated wild land crop. These census figures for woods income contain no estimate of, or calculation for, the value of things which are associated with the woods, such as wildlife, recreation, beauty, sentiment; these are intangibles, and as such they are beyond the category of the economist.

Of course, a very potent reason for neglect of this item by the agricultural economist is that the average revenue per farm received from woodlands is relatively small as compared to other crops, but this is not surprising in view of the lack of care and attention given to the average woodland and the lack of recognition which the farm woods has received as a part of the agricultural economy. The census figures for 1935 show 185 million acres in farm woods, and 60 percent of this is reported as grazed woodland. An unknown but appreciable part is burned over every year.

Agriculture is governed by a ground line philosophy. This is a natural and logical development, because most farm crops—crops to be harvested annually—are adapted to the plan of cutting off at the ground line that which the soil produces. When the crop is harvested, only the soil plus the crop residue is left. The farmer clears off the residue either by burning or by plowing under; he starts the next crop from seed or perennial roots. It is not surprising to find that many farm woods are what foresters call "coppice woods" which means that the existing woods have come from sprouts. Coppice woods are produced by clean cutting just as a crop of asparagus is cut; the next crop is allowed to spring from the roots of the trees removed.

This sort of woods management is in keeping with the ground line philosophy of agriculture, but it is poor forestry. It produces very little revenue, and it is usually the wrong practice from the standpoint of silviculture, and silviculture is what makes a good paying forest. Foresters know that this ground line philosophy applied to the management of farm woodlands is wrong, and that it should be changed, and agricultural workers in the Soil Conservation Service know that this philosophy is wrong. Fortunately, more and more farmers who are cooperating with the Soil Conservation Service now share another viewpoint. They have a different philosophy represented by two objectives which the Soil Conservation Service uses: Every acre of land must be treated in accordance with its needs and adaptabilities; and, every part of the farm must produce its share of the farm income.

In view of this farmer and agricultural philosophy which is the background of our agricultural history, a fence around the farm woodland is not sufficient for erosion control. It is not a sufficient means of making

the farm woodland produce its share of the farm income. A ground line philosophy is absolutely inconsistent with profitable forestry, and it does not result in an erosion-resistant vegetation. Why? Because a clean-cut woods or a woods clean cut from the standpoint of commercially valuable trees, creates temporary waste. The values are gone. There is no visible value left even though such a cut-over woods may have a potential value. Even the most optimistic forester cannot assign very much tangible value to a new slashing. Such a woods, without an appreciation of its potentialities, without a realization that eventually it will produce more as woods than in any other crop, will surely be neglected. It will be grazed and it will be burned.

Many farmers who protect their woodlands from fire and domestic animals ruin them by neglect, or what amounts to the same thing—injudicious cutting. A good woods can soon be converted into an economic desert of worthless species by the application of the axe guided by a ground-line philosophy. Fire, grazing, and neglect are the three horsemen which ride roughshod through the farm woods, and a sufficient explanation of why they ride and ruin is this ground-line agricultural philosophy. The farm woodland, to be useful as an erosion-control measure, requires more than a fence around it, more than fire protection. It requires the exclusion of the three horsemen. A fence doesn't stop them, but a fence plus a satisfactory income from the woods will keep them out. And a satisfactory income from the woods can be brought about only by the intelligent application of silviculture as one of the tools of the agriculturist.

Let us not deceive ourselves into thinking that we have accomplished something for erosion control when we have built a fence and a fire line around the woods. That is the first step, but it is only the first step. Having done that, the forester is in a position to show the farmer the possibilities of silviculture and what it can do as a part of agricultural practice. The capital stock in the farm woods is the soil plus the growing stock. The soil is the crumbly, porous, water receptive floor of a woodland free from fire and trampling stock. The growing stock is made up of a whole galaxy of trees from seedlings to mature trees ready to cut. Only proper management of these two elements will enable a farm woodland to meet its share of the farm income and thereby earn the right to a permanent place in the land-use program of the farm.

Very few farms in the timbered country can produce a satisfactory standard of living for the farmer without his getting a proportionate share of income from the woods. Soil plus growing stock plus management are the three factors which must be recognized as determining the success of the farm woodland as an erosion-control agent. We must get the farmer to abandon the ground line philosophy as applied to the woods; he must raise his sight from the ground to diameter breast high. A fence around the farm woodland is not a guarantee of permanent land use. Fire, grazing, and neglect can be overcome only by manipulation of the three factors—soil, growing stock, management. The ground line philosophy must give way to "woods appreciation."

In an article on stimulation of hardwood cuttings by means of synthetic growth substances, V. T. Stoutemyer states that "the cuttings should be made of firm, well ripened wood, and, with some subjects, preferably of a somewhat larger diameter than that often used."

Soil, Plus Growing Stock, Plus Management.

This Oregon Prune Orchard Sleeps Undisturbed Under a Protective Blanket of Straw. A Hint of What Can Happen When the Soil is Left Bare is Given at the Right of the Picture, Where Washing is Taking Advantage of the Lack of Cover.

THE USES OF MULCH

By C. R. Enlow[1]

THE opportunities for using mulch on the farm in connection with erosion control are numerous. In some sections of the country many farmers in past years have mulched orchards and vineyards with straw, hay, and other materials in the attempt to improve the organic content of the soil. During the past few years, with the advent of a soil-conservation program, interest in mulch has increased; this is true particularly in those areas where it is difficult to grow vegetation that will afford erosion control and soil improvement, such as old orchards or groves, or where competition for moisture makes it difficult to grow a cover crop without reducing the production of the cash crop. The production of grapes without irrigation in California affords an illustration of the latter.

Frequently the mulch crop is grown and not harvested, but is allowed to remain on the land for protection against erosion. Oats, barley, Sudan grass, or other nonhardy annuals planted in late summer will make fairly good growth before being killed by winter freezes. Such material offers good protection against winter erosion and has the advantage of being anchored to the soil so that it is not washed or blown away. The dead plants do not offer competition for moisture in early spring, but instead help to retain it for use by the main crop grown on the land during the summer. This practice is often followed in the vineyards and berry patches of Michigan.

In humid sections most farmers recognize the advantage of mulch in establishing grass, legumes, or other erosion-control vegetation on eroded slopes, in gullies, on galled spots in pastures, and under other conditions where moisture conservation is important. A light mulch over a seeding of grass prevents the seed from washing away and retains the moisture until the seed has germinated and the grass plants are well established. Straw, manure, legume hay

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of no economic value, or even weeds or brush can be used.

In semiarid regions a mulch of wheat stubble, Sudan grass, millet, or similar plant residue gives excellent protection to grass seedlings. The limited moisture supply is retained to aid germination; destruction by soil blowing is avoided; winter snow is retained; summer soil temperatures are lowered; and conditions in general are made more ideal for growing grass. Merely drilling grass seed in wheat stubble, where moisture is plentiful and weeds are not too abundant, is an excellent method of seeding. The rod weeder may be used to destroy weeds and keep the plant residue on the surface; this will provide mulch that is so essential to the successful establishment of grass.

Many citrus groves in California are mulched by the simple method of mowing the weeds and grasses that grow in the groves and leaving the mowings on the ground to protect the soil from erosion and aid in conserving moisture. Olive groves grown without irrigation are always a problem from the erosion-control standpoint. This is because of the sparse cover growing under the trees. They can be handled very successfully, however, if mulching materials are available. Fruit growers in Michigan are hauling mulch many miles for use in their orchards; and New Jersey orchardists mow salt grass from marshy flats to use in protecting the highly erodible soils on which their fruit trees grow.

Frequently, in order to dispose of the water from terraces, it is necessary to use terrace outlets or waterways almost immediately after construction. It is true that the newly prepared outlets may be covered with sod and thus satisfactorily protected against erosion; but the operation is expensive, and sometimes sod cannot be obtained. Seeding and covering with mulch is less expensive, although it is necessary to protect the mulch with chicken wire until the vegetation has become established.

If all our soils had the proper physical structure and were high in organic matter, it should not be necessary to resort to the use of mulch to protect them. Yet, invariably, the production of specialized crops almost prohibits the use of a soil-conserving rotation. When these crops are grown on sloping land and clean cultivation is practiced to control weeds and check the evaporation of soil moisture the soil is exposed and very vulnerable to sudden dashing rains; in such instances all possible methods of saving the soil must be employed.

While mulching has excellent erosion-control possibilities, the danger of spreading plant diseases, or harboring insect pests and rodents through its use should be investigated before the practice is advocated on a wide scale. It is recommended, therefore, that the assistance of the State experiment station authorities be solicited in order to avoid any complicating problems that might arise from our efforts to control soil erosion.

The following excerpt from an article by Kramer and Weaver [2] illustrates admirably the value of mulch in conserving soil and water:

"The wonders worked by litter are indeed remarkable. On a barren soil where the upper 6 inches had been washed away, 41 pounds of oven-dry forest litter were placed over 36 square feet of soil. Although this material could hold but .35 inch of rain when fully saturated, yet it reduced rainfall runoff from 36.6 percent (control plot) to 16.2 percent of the total 55 inches precipitation. The greatest reduction in runoff occurred when the rains were hardest and the most water fell. Erosion was reduced from 70.5 lbs. to only .84 lb. per acre (Meginnis, '35). Thus the capacity of litter to absorb rainfall is of little consequence compared with its power to bring about absorption of water by the soil. This is accomplished largely by keeping the soil pores from becoming clogged by silt particles being thrown into suspension, as regularly occurs when heavy rains beat upon bare soil. Weeds are not harvested except in times of great distress. They remain on and in the soil. They function during life and after death."

Kramer and Weaver continue, quoting Seitz,[3] in an effective two-paragraph discussion of weeds and topsoil:

" 'Weeds are the wound dressers of the soil. Whenever man or nature makes a scar, the vigorous, coarse-fibered weeds find the spot and straightway mend the injury. Hated and much objurgated, the weed, of whatever breed, is one of the most useful forces in nature. The farmer regards it as a foe, the gardener as a nuisance. In truth, it is a friend that persists, regardless of ill treatment and attempts at extirpation. Soil, to preserve its strength, must be protected with some sort of covering, otherwise the rains leach it, or wash away the precious particles of mold that make it productive. Man neglects this factor in his dealing with the earth. . . . great damage results, and much more would follow but for the energy of the weed family."

[2] Joseph Kramer and J. E. Weaver, Relative Efficiency of Roots and Tops of Plants in Protecting the Soil from Erosion. Bulletin 12, Conservation Department of the Conservation and Survey Division, University of Nebraska. January 1936.

[3] D. C. Seitz: Weeds—Nature's Wound Dressers. Outlook, Nov. 24, 1926, p. 405.

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Agroecology as a Basic Science of Soil Conservation

By Basil M. Bensin[1]

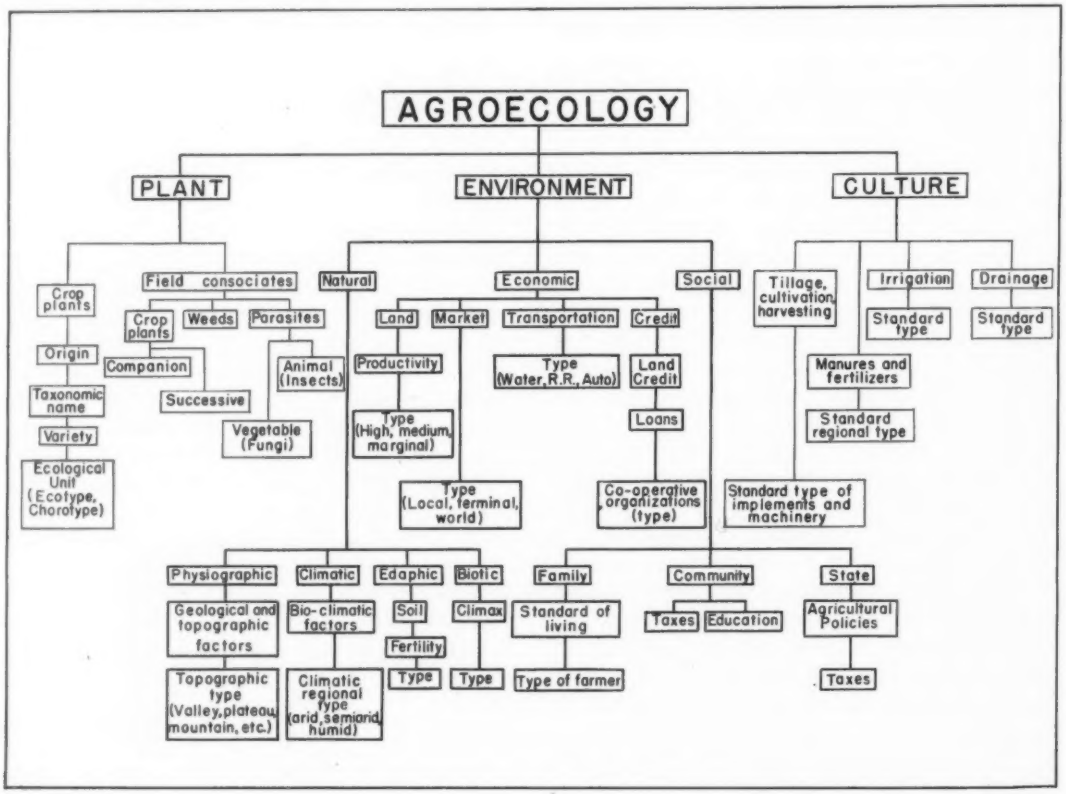
AGROECOLOGY is the applied ecology of agriculture. It may be applied to economic plants (plant agroecology), and it may also be applied to the study of farm animals (animal agroecology).

The term "agroecology" was first proposed to the Czechoslovak Botanical Society and to the International Plant Breeders Association at Prague in 1928 and then to the International Agricultural Congress at Bucharest in 1929. The objective of agroecology as a basic part of agronomy is to analyze relationships between species and types of crop plants and their environment. There are three main phases to be considered: (1) Crop plants and their regional types, (2) regional environment as it affects crop plants, and (3) culture as the dynamic factor in agroecology, comprising the agrotechnique of the region.

Plant ecology in a broad sense is usually defined as the science of the relationship of plants to their environment. In the early stages of development of plant ecology (about 1895), it dealt chiefly with observation and description of plant societies of various geographical regions. Plant ecology has gradually developed into the experimental science of the interrelations of plants and their environment.

Ecological research designates definite ecological types of plants in their relation to their environment as ecads (Clements 1908), ecotypes (Turesson 1922), climotypes (Rosanoff 1928), and chorotypes (Bensin 1928). The last mentioned term indicates regional

[1] Dr. Bensin, a graduate of the University of Minnesota, has a varied experience which includes agricultural explorations in Central Asia and Mexico. This paper was suggested by a lecture which he recently delivered to the Graduate School, U. S. Department of Agriculture, Washington, D. C.



ecological types. In each region there are some dominant plant societies, which give a characteristic feature to the landscape of the region and which are designated as climaxes of it. In the relation to widely different geographical regions, those ecological types of plants of the same species but with distinct and characteristic features of successful adaptation to environment have been designated as geographical races (Komarov 1901) and geo-ecotypes (Gregor 1933).

Complete agroecological studies should include not only natural but also economic and social elements of agricultural environment as significant factors for agricultural production. Agroecology deals with definite regional types of farm plants and animals, types of farmers, types of farming, and types of implements and machinery used. Hence, regionality is a basis for agroecological studies. The agricultural region (*agrochora*) comprises the complex of environmental factors affecting agricultural production, agrotechnique, and regional types of economic plants (*agrochorotypes*).

Analytical agroecology includes both qualitative and quantitative analyses of the crop plants of the region. Qualitative agroecological analysis consists of the systematic studies by means of field observation of and experiments with the agrochorotypes of crop plants. It leads to ecological diagnosis of crop-plant factors as found through detailed studies of the origin, taxonomy, genetics, anatomy, cytology, and physiology of the crop vegetation in its relation to environment, as well as rhythm of growth (phenology) and productivity (yield). This diagnosis needs to evaluate all parts of the plant—stem, leaves, branches, and roots, as well as flowers and fruits—in relation to productivity and the specific factors affecting growth and yield in the region. Therefore, agroecological diagnosis is more complex than taxonomic description and requires experimental test. It also includes the evaluation of ecotypes, the study and classification of which has become one of the important phases of experimental taxonomy. Likewise, qualitative agroecological analysis, based upon diagnoses of many agroecotypes of our cultivated and native economic plants, should give the most valuable material for comparative studies and for establishing the ecological classification of our regional varieties and ecological types of crop plants.

Quantitative Agroecological Analysis comprises frequency of analyzed and described regional types in a certain geographical and agricultural region in its relation to that of other crops and varieties grown there. Technically this frequency is in some cases revealed by crop statistics and acreage of arable land of the region. In other cases the ecologist must use his own judgment. In this connection, we should emphasize the significance of consociation. According to my conception the term "consociation" designates in a broad sense all living organisms, plants, and animals found on the same field, including companion and successive crops planted by farmers, weeds, and parasitic fungi and bacteria living on the plant or in the soil. Presence of the last-mentioned has quite a decisive effect upon agricultural production.

Crop rotation systems really indicate agroecological plant succession, planned by the farmer according to proper agricultural production and marketing in the region and on a given farm. The prevailing regional type of agrotechnique, as well as the type of farmer himself, his personality, education, energy, character, and even specific features of the race to which he belongs, should be considered as an essential factor of agriculture.

Determination of edaphic factors (soil) is essential to a study of plant relations to the soil and requires a series of special ecological investigations. It naturally involves detailed analysis of physical and chemical properties of soil (edaphology). Another agroecological phase of investigation includes experimentation with perennial crop plants to find a properly balanced ecological mixture in plantations. This fundamental ecological principle already has been applied in silviculture in many countries with apparent success. Likewise, ecological principles of plant competition, succession, and plant climaxes should be considered with special reference to the soil conservation problems of various regions. Standard grass mixtures for ground cover composition should be established only after a proper agroecological analysis. Tests of new introduced plants should be arranged in various regions to determine the degree of ecological adaptation which they may possess before the actual introduction and recommendation to the farmer.

The experimental methods of agroecological research should be based upon statistical analysis of field observations with special reference to correlations noted in the ecotypes, including correlations for all parts of typical plants. Problems of soil conservation require close study of the ecotypes of soil-holding and soil-building plants. Such studies of ecotypes are of special value to the development of soil conservation and hill-culture in this country.

The most distinctive ecotypes appear in tropical countries where polymorphic character of plants is quite common. In my studies of the vegetation of

northern Mexico, I discovered some striking ecotypes among the native plants of the semiarid region of the northern part of the Soto la Marina River Valley, in the State of Tamaulipas. Within a short distance from the shore of the Gulf of Mexico there are great changes in the physiognomy of vegetation. Here within a small area, ecotypes of open valley, hill, and coastal plain regions are modified as to height, general appearance, and adaptation to the microclimatic conditions. I noted ecotypes of *Randia aculeata* L. (synonym: *Randia mitis* L.), *Cordia Boissieri* DC., *Leucophyllum frutescens*, I. M. Johnston, and *Karwinskia Humboldtiana*, which may have significance as soil-holding plants adapted to certain types of soil. *Randia aculeata* (Syn. *R. mitis*) shows distinctive ecotypes: (1) abores-cens, (2) erecta, (3) prostrata.

Randia, of the family Rubiaceae, is a common coastal plant throughout the West Indies and in southern Florida. In Puerto Rico, according to Britton and Wilson, it is a vigorously branched shrub 1 to 3 meters tall, or may become a small tree of 10 meters. In Bermuda it is a shrub only, and 1 to 3 meters tall. Standley, who studied the trees and shrubs of Mexico particularly, refers to it as a shrub 1 to 3 meters high. Tree forms of *Randia aculeata* L. (synonym, *Randia mitis* L.) are characteristic of the open-valley chorotype. *Randia aculeata* (syn. *Randia mitis*) is a dwarf shrub in upland hills, and grows prostrate and cushion-like along the sea coast in Soto la Marina region.

Similarly, *Cordia Boissieri* is tree-like in the river valleys, a high bush in open valleys, and a dwarf bush on the coastal plain. *Karwinskia Humboldtiana* is a high bush in the valleys and a dwarf bush with somewhat reduced leaflets on the coastal plain. *Leucophyllum frutescens* is 2 to 3 meters high on the open valleys and 35 to 50 centimeters on the coastal plain. Thus chorotypes as ecological units correspond to so-called "geographical races" of the same species found under various latitudes and sometimes distinguished as taxonomic subspecies.

Ceniza, *Leucophyllum frutescens* (Berl.) I. M. Johnston, of Scrophulariaceae is a highly adapted xerophyte, with whitish pubescent obovate leaves and pink flowers, and should be considered as a most typical element of all xerophyte formations of this region. It is a shrub varying in height from 50 centimeters to 2.5 meters. In this low plateau region it is not more than 1 meter high, always growing as a dominant in the societies where it appears, and always indicating calcareous soils.

Cordia Boissieri, commonly called "Anacahuita" in Mexico, belongs to the Boraginaceae, and is quite a popular shrub among the natives. It is very handsome, especially when covered with white flowers, somewhat resembling the Rhododendron in appearance. All parts of the tree are aromatic. A jelly made from the fruit is much used as a remedy for lung diseases, coughs, and colds. A decoction of the leaves is a popular domestic remedy for rheumatism, and is generally employed in the treatment of bronchial infections. The leaves are oblong, cordate at base; flowers in small dense cymes; fruit ovoid 2.5 to 3 centimeters long, reddish brown, and shining, the flesh sweet and edible, but if eaten raw, it is said to cause dizziness, as if one were intoxicated. The wood is used for making yokes. This plant is well adapted to various soils of the region, but in Mexico it is polymorphic, varying in its form, as Standley states, from a tree 8 meters high, with the trunk 20 centimeters in diameter, to a small bush, found among other xerophytic shrubs.

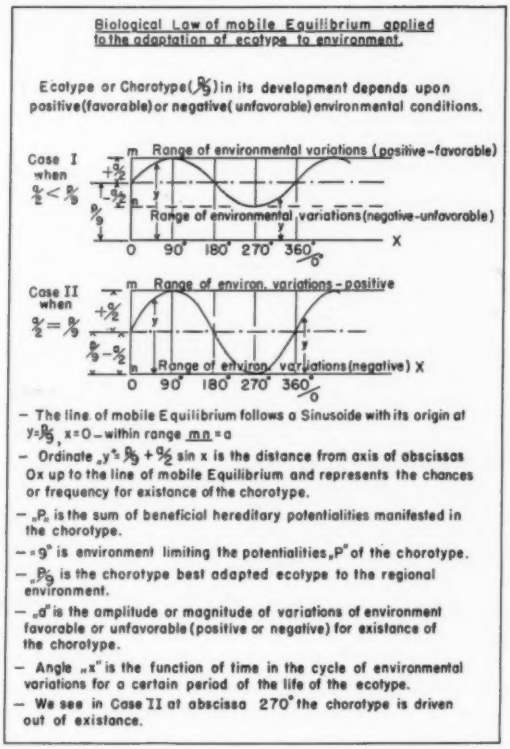
Biological Principles of Agroecology

The general principles of agroecology are the same as those of general biology. In my mind the fundamental principle of ecology is a law of interchangeable or mobile equilibrium, stated as a natural philosophical principle by Herbert Spencer, and later proved and developed in experimental biology and formulated by two Russian biologists, A. Elenkin and A. P. Iljinsky (1921).

According to Spencer, the life of the organisms consists in maintaining *mobile equilibrium*—a balancing between external and internal factors, a continued adaptation of internal relations to external, or a mechanical reciprocity between the organism and the environment. The principle of equilibrium may be applied in physics and chemistry as well as in biology. An example in physics is seen when *force*, *motion*, and *gravity* are related. Ordinary scales are the very best instruments for demonstrations of equilibrium, as while we are weighing some substance and gradually obtaining the balance of both pans with the amplitude of motion equal to zero.

In chemistry every chemical reaction is designated as an equation with two balanced parts on both sides of the equation—chemical equilibrium. Likewise we have electrical equilibrium in electric generation.

The Russian biologist Elenkin dealing with symbiotic phenomena in the life of lichens, arrived at definite conclusions about the relation between certain organisms and their environment. He developed formulae representing the fundamental interdependence of the organisms of the same community, and showed that


Biological Law of mobile Equilibrium applied to the adaptation of ecotype to environment.
Ecotype or Chorotype(P/9) in its development depends upon positive(favorable) or negative(unfavorable) environmental conditions.
Case I when
m Range of environmental variations (positive-favorable)
Range of environmental variations(negative-unfavorable)
0 90° 180° 270° 360°
X
Case II when
m Range of environ. variations - positive
Range of environ. variations(negative) X
0 90° 180° 270° 360°
- The line of mobile Equilibrium follows a Sinusoide with its origin at y=P/9, x=0 - within range mn = a
- Ordinate „y" = P/9 + a/2 sin x is the distance from axis of abscissas Ox up to the line of mobile Equilibrium and represents the chances or frequency for existance of the chorotype.
- „P" is the sum of beneficial hereditary potentialities manifested in the chorotype.
- „9" is environment limiting the potentialities „P" of the chorotype.
- „P/9" is the chorotype best adapted ecotype to the regional environment.
- „a" is the amplitude or magnitude of variations of environment favorable or unfavorable (positive or negative) for existance of the chorotype.
- Angle „x" is the function of time in the cycle of environmental variations for a certain period of the life of the ecotype.
- We see in Case II at abscissa 270° the chorotype is driven out of existance.

the community relationship of two or more organisms is in mobile equilibrium, dependent upon the external factors of environment (light, temperature, humidity, and chemical elements). Elenkin's formulae provide a basis for a law of mobile equilibrium as applied to biology.

Ecology deals with the best adapted regional types of vegetation, designated by various authors in different ways: *geographical species* (Komarow, 1901), subspecies (Wettstein, 1898), the ecad (Clements, 1908), habitat type or ecotype (Turesson, 1922), the modification-variety (Koso-Poljansky, 1920), clymotype (Rosanof, 1928), chorotype (Bensin, 1928), agroecotype (Gregor, 1933).

The idea of the chorotype as a fundamental concept in agroecology is based upon Elenkin's biological law of mobile equilibrium. Even if the agrochorotypes are geographically distant, corresponding to *geographical* races of Komarow and *geoecotypes* of Gregor (1933), they can be transferred to similar agrochora and tested. This test would show capacity for establishment in a plant population or survival in an extreme habitat.

Each chorotype should be carefully described with reference to its behavior to the environment and its morphological and anatomical features. Such experimental tests may indicate cytological differences in its chromosome constitutions, as it has been shown in *Phleum pratense* (Gregor and Sansome 1930).

In my opinion we should describe the noted character of all vegetative organs as *modifications* (designated sometimes as continued modifications) as follows: The plasticity of various plants grown under different environmental conditions as a result of their reaction to an environment may be different, some species being *monotypic*, *oligotypic*, *polytypic*. Another principle, which can be considered as a basic fact in ecological studies, is *periodicity* among the species of the same genus. Periodicity has been designated by Komarov (1908) as a series of the species closely related genetically. Later this idea was developed by Vavilov (1922) who stated the so-called *law of homological series*, not only for the closely allied species but also for related genera. The principle of periodicity in biology is logically the same as in chemistry, where periodical systems of elements were established much earlier by Mendeleev (1869) and now are universally accepted. These concepts as applied to agroecology show that *agrochorotypes* of farm crops are very closely related to taxonomy, plant physiology, and genetics.

The third principle used in agroecology is *correlation*. This, in a broad sense, has been applied as a logical principle, introduced by Quivier and later by Radl (1901), for parallel studies of two fluctuating factors, closely related but remaining independent, which are without clear interaction. Besides this, there is some organic and functional relationship between the parts of an organism which are clearly dependable one upon another, that is, in close correlation (epharmony). *Epharmony* really is an indication of the state of the equilibrium within the chorotype of single function and development of plant organs and, as a result, a certain adaptation of these, as a definite characteristic feature of the vegetative organs, is observed.

In the case of unusual conditions unfavorable to the struggle for existence, there arises a special kind of adaptation as a result of *epharmonic convergency* which is very significant for the life and character of the best adapted individuals and strains. This should be the object of special attention and study by agroecologists in such cases as dry season or winds affecting growth and development of crop plants. Those plants remaining after a period of such unfavorable conditions of growth should be used as valuable material for

(*Continued on p. 152*)

Kudzu Repairs Erosion-Torn Areas In South

By A. T. Semple[1]

ON a recent trip to several of our project and camp areas in Georgia, Alabama, and Mississippi, I was very much impressed with the value of kudzu for erosion control. The emphasis which R. Y. Bailey, now regional agronomist, placed on the use of this plant, starting on the Dadeville project in 1934 and spreading to most of the region, has paid big dividends.

Kudzu has a peculiar capacity for completely covering and stabilizing gullies, galled areas, highway and railway cuts and fills, ditch banks, and terrace outlets. Apparently it has no close competitors in this field. Its valuable place in perennial strips in the Southeast is described in Farmers' Bulletin No. 1776, Strip Cropping for Soil Conservation.

Speaking in round numbers, Mr. Sloan, manager of the Greenville, Ala., project, made a statement to the effect that the most severe erosion on most farms occurs on about 10 percent of the area. This applies to the average farm of less than 100 acres with as much as 25 to 50 percent of the area in woodland, some bottomland pasture, and the balance principally corn and cotton land, with the steeper slopes of the hillsides abandoned to a scant growth of such plants as pine, persimmon, broomsedge, poor joe, and aristida, with considerable areas entirely bare. Gullies in these areas cut back rapidly into the better lands above and dump silt to bury the better soils in the bottoms. Thus the meager areas of productive soil are whittled away, and the operators approach complete dependence on other sources of income than the farms they live on.

With a cash and labor outlay considerably less than that made on average cropland, these abandoned areas which would do well to produce 5 bushels of corn per acre, can be made to produce 1 to 1½ tons per acre of excellent kudzu hay. Considering the low income of such farms, the possibilities of marketing such hay immediately come to mind, but other aspects of the situation point strongly to the importance of home consumption.

Like tomatoes, sweetclover, and other now valuable crops, kudzu has had to overcome a lot of prejudices and misunderstandings. A proposal made several years ago that series of parallel wire fences be erected to serve as trellises for kudzu and provide grazing for cows seemed almost ridiculous at that time.

I was of the opinion that mowing kudzu and making it into hay would be a rather difficult and disagreeable job and that most farmers would not be bothered with it. And so I was delighted with the quantities of baled and stacked kudzu hay of excellent quality which I saw on the Anniston and Dadeville projects. In several places haymaking was under way. It is easier to cure and no more difficult to handle than a heavy growth of red clover, according to my experience. One farmer's enthusiasm over his kudzu crop beat anything of its kind that I had ever seen. As proof that kudzu haymaking is no flash in the pan, I should like to tell more than is possible within this space, particularly about 800 acres of kudzu meadows between Wetumpka and Montgomery, Ala. This is part of a commercial mixed-feed enterprise, which was started with 60 acres of kudzu in an abandoned pecan orchard. The one thing here that should be emphasized is that rotary hay loaders would not do the work. But when some fork-type hay loaders were located and put on the job, there was no more trouble. Incidentally, the rate of growth and appearance of pecan trees is very noticeably improved in contrast to exactly similar trees which have not had the benefit of kudzu.

Twenty years ago Charles F. Leach, of Monticello, Fla., was extolling the value of kudzu. Unfortunately, too little attention was paid to what he had to say. At that time the emphasis was being placed on the introduction of purebred livestock in the South, especially in areas which previously had been freed of splenetic (Texas) fever ticks. Far too little attention was paid to the necessity of providing this stock with sufficient feed of adequate quality. Consequently, they failed to produce profitably, in some cases not at all, and the great majority of farmers have gone ahead depending almost entirely on cotton and other annual crops as their main source of income.

As a result, next to pasture, hay has been one of the scarcest and most expensive products on most southern farms. Now that it has been found practical to produce hay from perennial legumes on land that formerly

[1] Assistant head, agronomy and range management section, Soil Conservation Service, Washington, D. C.

Kudzu Hay Cures Quickly, Can be Baled from the Field and Handled Easily with a Fork. If a Hay Loader is Used, it Should be of the Fork Type.

was less than worthless, it will be possible to do away with the laborious practice of fodder pulling and the soil-depleting practice of growing annual legumes such as soybeans and cowpeas for hay. Their removal for hay leaves the soil poorer than it was before. In addition, the soil humus is destroyed, the ground is left bare in the process of seedbed preparation, and there is scant cover after the hay crop is taken off. As these annual hay crops usually follow oats, they can be replaced with lespedeza or other summer-growing vegetation which does not necessitate working the soil, which gives it adequate cover throughout the season, and which may be plowed under to improve the cropland preferably after being grown on the land for at least 2 years. Phosphate must be used to provide for a satisfactory growth of lespedeza.

With this inexpensive hay from former waste land and with enough bottomland pasture to carry a couple of cows and supply the workstock with cheap forage about two-thirds of the year, the farmers will be relieved of certain needs for cash expenditures and will have provision for a better living for their families. Thus they will be in a better position to carry out an adequate program of soil conservation. Consequently, I feel that every reasonable effort should be made to induce the greatest possible number of farmers in the Southeast to grow kudzu. In addition to planting gullies and galled areas in the most favorable spots, with ample provision for fertilization and cultivation, during the first year or two terrace outlets and other drainageways requiring perennial cover should be selected for kudzu—this in order that 2 or 3 acres of this valuable legume hay may be planted on the average farm.

Within 3 years, the farmers will be able to cut hay from their kudzu patches, will be convinced of its value, will have a source of crowns for planting the other areas needing such treatment, and will be ready for other steps in a complete erosion-control and proper land-use program.

Grover F. Brown, regional agronomist, Region 1, notes that saltgrass hay, washed on to New Jersey beaches by wave action during storms, is proving a source of fine quality mulch for orchards and vineyards. The mulching practice is being carefully studied and it is believed that it will play an important role in erosion control on the sandy soils of fruit-producing areas.

"BEFORE AND AFTER" ON AN OHIO DEMONSTRATION FARM

By F. E. Charles[1]

IN November 1936 the Soil Conservation Service, cooperating with the Ohio Agricultural Extension Service, set out to carry soil conservation practices to southeastern Ohio farmers outside project and camp areas. Farmers were demanding help, partly, no doubt, because they had read and heard much of erosion control work. To meet the situation, R. L. Bazler, soil conservationist, was delegated by the Service to replan those farms recommended by the Agricultural Extension Service and the county land-planning committee.

Fifty-three farms in a score of southeastern Ohio counties have been completely replanned for soil conservation. The 53 farms have a total area of 8,746 acres. The revised plans provide for cultivation on 2,885 acres. This cropland in proportion to entire farm acreage would not seem large in Iowa, Illinois, or Kansas. But southeastern Ohio is an area of sharply rolling topography where slopes commonly run up to 30 percent, with considerable untillable land on the steep slopes and sharp breaks. Prevailing soil types are highly erodible. Needless to say, erosion is serious on cultivated fields and overgrazed, mismanaged pastures.

Strip cropping has been considered one of the most suitable soil-saving practices for this section. For a generation or more, a few far-seeing farmers have been following a system of strip cropping, but until recently most of their neighbors have failed to see its advantages.

As evidence of the current swing to this method of conservation farming, Mr. Bazler tells us that of the 2,885 acres of cropland in the 53 replanned farms 2,408 acres are to be strip cropped—1,008 acres already are being farmed by the strip-crop system. The 477 acres of cropland not scheduled for such treatment is bottom-land or flat land on which strip cropping is unnecessary.

Other major land-use changes planned on the 53 farms include the following: 643 acres, formerly used for cropland, are to be used only for permanent pasture; 253 acres are reserved for permanent meadow; 57 acres are set aside for reforestation; 117 acres of former pasture will be returned to forest; and a total of 906 acres of woodland will be fenced and protected from grazing by livestock.

[1] Regional information officer, Soil Conservation Service, Dayton, Ohio.

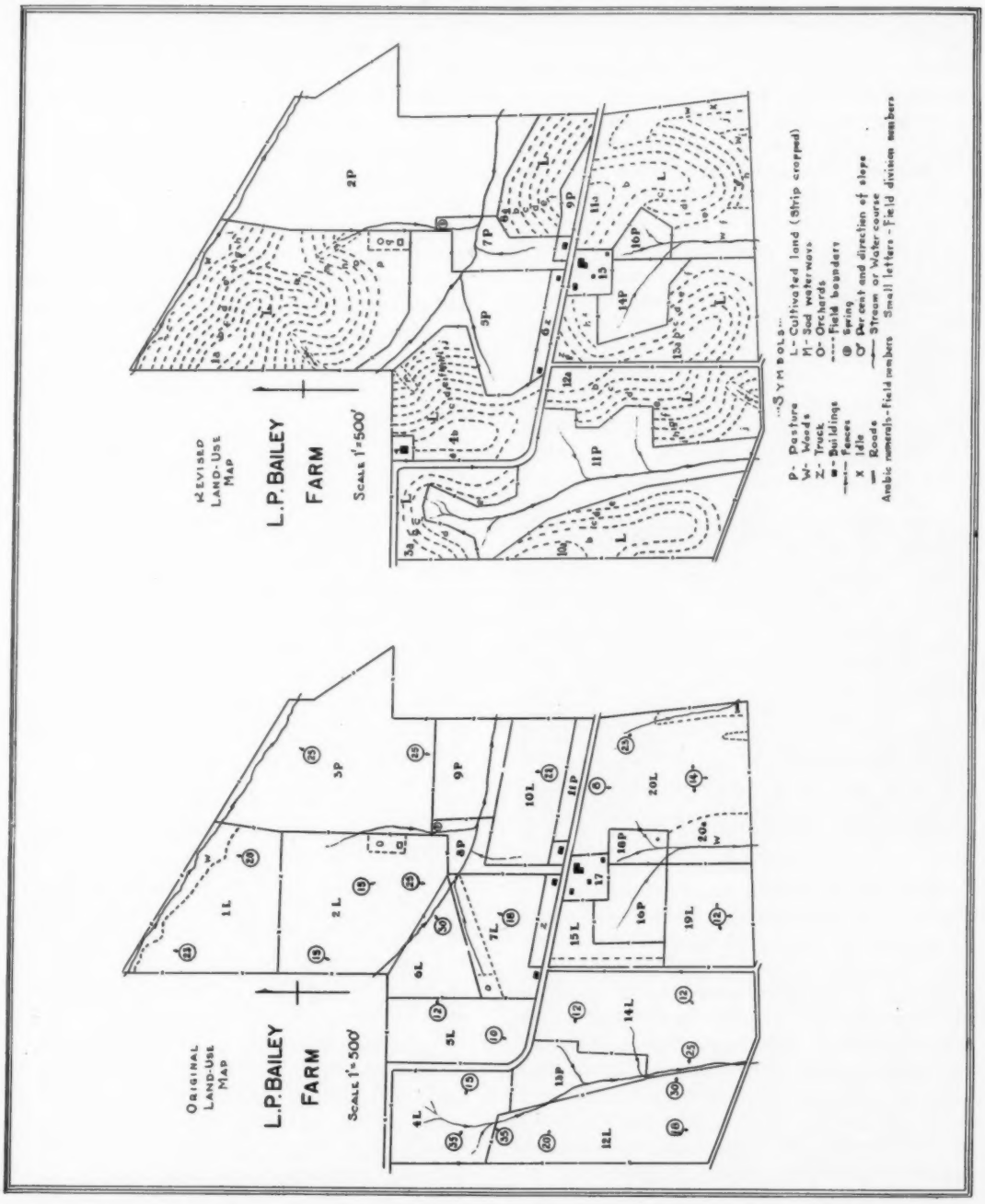
It is obvious that the farms have been carefully selected by the Agricultural Extension Service. This is how it works:

Farmers ask the county agent for help on their erosion problems. The county agent studies the farms and the farmers, and determines whether satisfactory demonstrations can be developed. Farms must be typical of the area, located prominently, and suitable for demonstrating several practices. Farmers are informed in detail of the responsibilities involved. If it appears that a demonstration can be made on a farm, the county agent obtains information on previous land usage, the existing cropping plan, farm manure and fertilizer previously used, liming practices, livestock on the farm, and so on. He then consults the county land-use committeemen for final approval. A request is then made, through the extension soil conservationist, for the assistance of a project technician in planning the farm.

With the counsel of the county agent and Agricultural Extension Service specialist, the technician replans the farm. That is his sole responsibility, except for a reasonable amount of "follow up" to assist the farmer in developing the plan.

To see how the demonstration farm plan works out in actual practice, let us consider a typical example, the Bailey farm of Tacoma, Belmont County. Here is one of the better and larger farms in the community—250 acres. Once owned and managed by the late L. P. Bailey, prominent Jersey cattle breeder and master farmer, this farm has been something of a model for its neighbors. It is accustomed to serving as an example. It was purchased in 1886 by the elder Bailey and has been a dairy farm for many years. Much against his wishes, but because his wife insisted, L. P. Bailey traded a thresher for a Jersey cow and calf and a bull. From that the Bailey herd has grown to 100 head, with 50 cows in the milking herd.

For 30 years L. P. Bailey's Jerseys grazed the farm extensively; hay and concentrated feed were purchased. Then came the war and high prices. Everyone, including the Baileys, broke up sod to produce grain. Even after the war, with prices still high, they continued to farm the place intensively. "We had to do it, because we couldn't afford to buy high-priced



feeds," explained Alva C. Bailey, who, with his brother, Jesse, now operates the farm.

"It was in 1927," the Baileys explain, "that we asked the State university, through our county agent, to help us with a cropping program. We had to produce more of our own feed. We began farming on an intensive rotation of corn, oats, sweetclover pasture, wheat, and alfalfa (mixed hay), plus the use of lime, phosphates, and animal manures. We have used continually one 25-acre field near the barn for

silage corn, with a lot of manure and rye plowed down.

"Before we adopted that program, we bought tons and tons of feed. The new program of 1927 was a hundred-percent successful in producing the feed we needed. The corn, oats, and wheat furnished the grain and silage we needed for our dairy herd, for our hogs, and poultry flock. It worked fine, but in the last 2 or 3 years of this heavy grain-cropping program we sensed that something was going wrong. We didn't get the yields we thought we should and we noticed something else—more and more of our topsoil seemed to be washing away and accumulating against fences at the bottom of the slopes."

The Bailey brothers recognized it as sheet erosion, winter erosion, especially when their steep corn fields lay bare. Little gullies began to wiggle down the corn rows, fed by water from still smaller lateral fissures in the soil. It was obvious, too, that the soil was not as friable and granular as it was when broken out from sod. It was noticeably harder and tighter and seemed to absorb less water. Some neighbors claimed it was the use of tractors that was causing this.

To the Baileys these were telltale signs. They knew that the cropping program recommended in 1927 was the best known at that time. It had accomplished its purpose of providing the necessary grain and hay and roughage for that big herd of Jerseys. But the Baileys realized that something else had come into the picture. They concluded that it was erosion, and the unseen leaching and washing away of costly lime, phosphate, and manure. During farmers' week in the winter of 1936–37, they again went to the university and their county agent. The Baileys are that sort—they take their problems to the university.

The result was that R. W. Lang, Belmont county agent, asked Conservationist Bazler to replan the Bailey farm for soil conservation. Action was what the Baileys wanted, so together they got busy. Look at the accompanying farm plans and you'll see that the conservationist asked the farm managers to make some fundamental changes in their cropping program. The Baileys were willing to follow the revised plan, if the soil conservationist and the university specialists thought it would accomplish the purpose.

New plans installed contour strip cropping instead of square farming. They created 17 fields in place of the original 20. They called for relocation of fences, but the Baileys have built very little new fence; instead, they have used electric fences to permit temporary pasturage. Study of the original and revised farm plans will show that fences have been relocated to include most of the steeper land in pasture or woodlands.

Under the old cropping program, corn acreage increased gradually until it was 50 acres. "But our yields have not increased," the Baileys observed.

Under their soil conservation plan they reduced the corn from 50 to 35 acres and eliminated oats entirely. In its place they have grown wheat and winter barley, thus keeping more of the corn strips under cover during fall, winter, and spring. This fall they planted half their corn ground to wheat and half to barley. In spite of their reduced corn acreage, the winter feed supply has been equal to previous years.

The hay acreage was increased nearly 100 percent, and those Jersey cows can use it. Sixty tons of it was made into silage this year. The revised farm plan provides 100 acres of permanent pasture instead of the 50 acres available before, but it is all profitably used. Pasture was one of the problems in the old feeding program. The cropping plan provides for a 5-year rotation, with strip cropping, in fields 3, 4, 8, and 13, allowing one of these fields each year to be in temporary alfalfa pasture to supplement the permanent pasture in summer. This overcomes the weakness in the old cropping plan.

In years past the Bailey farm either produced or purchased annually a small quantity of alfalfa and sweetclover seed. The new plan called for meadow mixture seedings, and one of the first investments was over $200 for such seed—this in order to get some hay sods started for strip cropping. "That's a lot of money," Alva Bailey remarked, "but we wanted to do this thing right! We solved our production problem 10 years ago, now we'll do whatever is necessary to conserve the soil. We realize that it will take 4 or 5 years to get the plan in full operation. If this new plan holds the soil as well as the university cropping program produced feed, we'll be more than satisfied."

The rotation field strips are 70 feet wide, except on the sharpest breaks where they are approximately 50 feet. As others who lately have turned to strip cropping have found, the Baileys find the practice is holding the soil and is no more difficult than their old methods. Said one of several Bailey farm employees, who had just finished plowing out some strips: "It was a whole lot easier than I thought it was going to be." He was using a two-bottom plow with an all-purpose tractor and had been dubious about the operation until he tried it.

(*Continued on p. 147*)

A Jack for Pulling Soil-Sampling Tubes

By C. E. Fisher[1]

FOR some time we have needed a simple, lightweight tool for easy removal of soil tubes driven at depths ranging from 4 to 8 feet in obtaining soil samples. A jack of this type has been developed and is described on this page. Its chief advantages are ease and rapidity of manipulation, light weight, simple construction, and low cost. The lightweight jack makes it possible for two men readily to carry the equipment for obtaining soil samples.

The tool has two sets of jaws. One set is made of malleable strap iron. This set encases a second set, the grab jaws, which are machined from cold rolled steel shafting to fit snugly around the tube. The first set of jaws is fastened to the link bars on the lever by means of a bolt provided with an adjustable thumb nut. The grab jaws fit inside the strap-iron jaws and are fastened to them with tap screws.

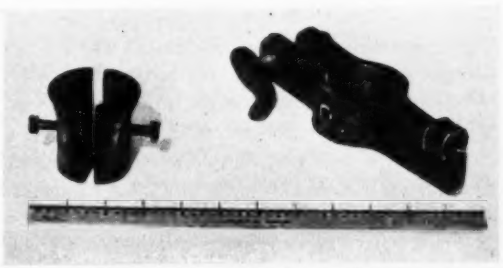
The wooden lever is constructed from seasoned, straight-grained oak, while the fulcrum and base may be made from any durable wood. The base is important because it keeps the jack in the proper position with respect to the tube and also tends to prevent the surface soil from crumbling into the sampling hole.

In sampling, the soil tube is placed through the hole in the base of the jack and driven down into the soil. The slanting fulcrum of the jack keeps the jaws clear of the tube during this operation. In removing the tube from the soil the jaws are clamped around the tube and held in position by means of a small drop flange on one of the strap-iron jaws. A downward pull on the lever tightens the grab jaws and lifts the tubes 4 to 6 inches out of the soil. When the operator pulls upward on the lever the jaws release and slide down on the tube. When the process is repeated the tube is quickly and easily removed from the soil. The jaws are released from the soil tube by raising the strap-iron jaws equipped with the drop flange.

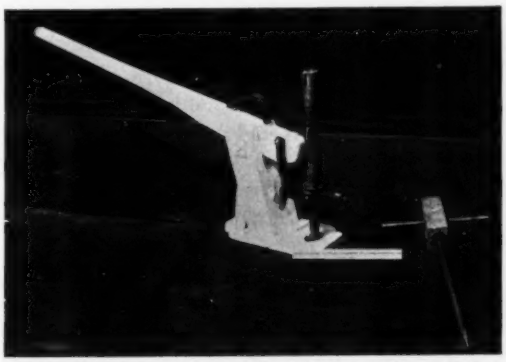
The grab jaws, when properly fitted, will not dent the tube in any way regardless of the weight applied on the lever. If the grab jaws should show a tendency to slip on the tube, the adjustable thumb nut may be manipulated to make the jaws fit snugly. If one is working with highly polished tubes, fine soil dust may be rubbed on the tube or jaws to prevent slipping.

[1] Assistant soil conservationist, Texas Agricultural Experiment Station, in cooperation with the Soil Conservation Service, Spur, Tex.

This jack has been in operation for the past 2 years at the Texas Agricultural Experiment Station at Spur, and has been put to severe tests. It was found that little effort was required to pull tubes driven to a depth of 12 feet in both wet and dry clay soils. With two men operating, the jack has an estimated lifting power of 2,000 pounds. The weight of the jack is 12 pounds and the cost about $5.



Grab Jaws and Strap-iron Jaws.



Jack in Position for Pulling Soil-sampling Tube. Driving Hammer on the Right.

(Continued from p. 146)

It should be said that soil on this farm is typical of Muskingum silt loam and loam phases. It erodes readily on the slopes that frequently run up to 20 percent. And it should be remembered that this farm, set up as a demonstration to neighboring farmers for conserving soil, is above the average of the community. Far from level, the land is not so steep and rolling as most of the surrounding farms. It is an ideal demonstration farm in several respects.

Since planning this particular group of 53 southeastern Ohio farms, the Soil Conservation Service has broadened the demonstration program in the Buckeye State. Scattered demonstrations have been set up in cooperation with the Extension Service, the Muskingum Conservancy District, the Farm Security Administration, and 22 State-owned farms.

DR. LOWDERMILK Writes on HOLLAND'S Contest With the SEA

HOLLAND teems with land-use problems; its greatest resource is its people, thus far equal to its problems. A land of 8,250,000 acres inhabited by 8,500,000 people, increasing 100,000 each year, must be well managed and treated to maintain its population. The area devoted to field crops is 2,500,000 acres and to grass 3,250,000 acres. Of the total 203,000 land holdings of over 2.5 acres in area, almost a third, or about 63,000, are less than 12.5 acres. Intensive cultivation is necessary.

Holland, once a part of Caesar's Gaul, is not divided into three but into two parts, namely, land above the high tide level and land below high tide level. The land above high tide level lies principally to the east, and comprises sandy lands and fixed dunes of the postglacial times. This part was, however, the scene of the first agriculture in Holland in Palaeolithic times, which we shall refer to later on. It is the area to which much government attention is given in reclamation, erosion control, and reforestation. The land below high tide level has special interest for us: It comprises about 46 percent of the country; it is the more fertile and productive part of the country; it makes Holland distinctive. For more than a thousand years the Dutch have carried on a contest with the sea for the occupation of the fertile alluvium spread out over the shallow sea bottom by the Rhine and Meuse Rivers of Germany and France. The Dutch have long been schooled in the handling of water and earth. They make water harmless by keeping it on the level by dykes and locks, and they early called the wind to their assistance by the development of the "Dutch windmill," a masterpiece in engineering with materials available to them. Inspection of a windmill, which has been in use for more than 200 years, and still in splendid shape, doing its work of lifting more than 25 cubic feet per second—8 feet when called upon—arouses a high respect for the mechanical ingenuity, as well as cooperative effort, of these people. The dyke associations are older than the Nation of Holland, and some of their regulations have precedence over laws of parliament, for fishing and agriculture were the first occupations of the people.

In modern times the economic structure of the country has changed from its early character; it is a complex industry. Agriculture, commerce, and transport, all play a complex and interrelated role in the country's affairs. While industry and shipping have developed from early times, agriculture still occupies a place of first importance in providing food supplies, raw materials for manufactured food stuffs, for supplying a means of livelihood for a population which industry, commerce, and shipping cannot employ. Between 300,000 to 500,000 employables are unemployed despite the large efforts in construction of reclamation projects, roads, and other works. Such is the impelling justification for the great Zuider Zee reclamation project.

In a land where there is scarcely 1 acre for each inhabitant it is interesting to have a census of farm animals. In 1936 there were 2,570,000 cattle, of which 1,455,000 were milching cows, 1,680,000 hogs, 295,000 horses, 655,000 sheep, 27,800,000 chickens, and 775,000 ducks. Along with this food-producing life are the fisheries which extend from the canals and local waters to the North Sea, and into the Atlantic Ocean as well. Fisheries supplied the market with 233,000 long tons of fish and sea foods.

When the history and the needs of this people are considered, one understands better the Zuider Zee project. It must be noted that the "Zuider Zee" is the name for the former body of sea water. The name is changed to Yssel Meer as the name for the new body of fresh water. The sea sluices discharge daily at low tide and close at high tide. Thus the original sea water is progressively diluted by the fresh waters of the Rhine discharge and of local streams. Within a few years the surface waters will be fresh, and suitable for much needed water supplies to surrounding municipalities.

Mr. van Panhuys of the Ministry of Works and Agriculture was designated to conduct us over the Zuider Zee project. This vast undertaking on the part of the Dutch people is one of the outstanding achievements of mankind throughout the ages. It is like unto the terracing of the mountain sides of Peru by the Pre-Incas. It excels the accomplishments of the ancient Peruvians, however, because of the dependence of success upon thorough planning, coordi-

NOTE.—This article is drawn from a letter recently received by the Chief from W. C. Lowdermilk, who is making a study of erosion conditions in Europe.—*The Editor.*

nation and utilization of great machines to accomplish a definite task within a certain time. The great dyke against the North Sea had to be completed and entirely closed before the next step could be taken. The Zuider Zee project will, when completed, put into cultivation 550,000 acres of fertile land at a total cost of approximately $1,000 an acre.

The question arises: Does this sort of thing pay—is it economical? Frankly I do not believe it is economical in the usual sense of the word. It has thus far been impossible to get a figure of the commitments of the Government to the project. One is put off by the statement that the funds used for this project were included within the general appropriation. The appropriations are not itemized for this project. It is a part of the general expense of the country as a whole.

Holland is hard pressed for sufficient land for her people. Thus the project can be justified on the basis of national effort for the maintenance of population, rather than the economics of cost and returns, acre by acre. The outstanding lesson to us is: If a nation will go to such lengths to push back the sea to make new land for its people, surely our people should take thought and spend what is necessary to conserve such land as we have.

The Zuider Zee project is not complete; only the Wieringermeer Polder has been dewatered and put into cultivation. This polder has an area of 20,000 hectares, or 50,000 acres, and represents the experimental polder, as a guide to the work in dewatering, and preparation for cultivation of the other three polders with an aggregate area of 200,000 hectares. Dykes are now being constructed about the Northeast Polder; the dyking was completed 10 years ago. The Wieringermeer Dyke, enclosing the first polder, was completed 7 years ago; the water was pumped out by two enormous pumping plants in about 6½ months, by August 21, 1930. The principal drainage canals were dug under water so as to provide for rapid drainage of the area as well as for transportation in the early days of the new land. After the land had been exposed, lateral drains were dug 2 feet deep, 35 to 60 feet apart, varying with the permeability of the soil. This work was done both by machinery and by hand labor. In a comparatively short time the area was drained of all surface waters, and the drainage of the water-logged soils was under way.

It is interesting to note that as soon as this newborn land was exposed to the wind and rain considerable erosion, both wind and water, occurred. The sandy portion of the polder near the sea inlet suffered from wind erosion, and the heavier clay soils of very gentle slopes suffered from water erosion under the fairly light rains of Holland. Water erosion was due principally to the long unbroken slopes of the former sea floor, and the low intake rate or infiltration capacity of the newborn land. Breaking up of the slopes into narrow sections by the digging of the lateral drains reduced this type of erosion to negligible amounts during this period.

The plans for the utilization of this 20,000-hectare area was well worked out before the dewatering, on the basis of a soils map, compiled from some 34,000 soil samples taken under water. The samples were collected by special equipment to depths of 1.5 meters, or nearly 5 feet. On the basis of mechanical and chemical analyses of these samples, a soils map was prepared before the water had been pumped away. It was thus possible to plan the pattern of drainage canals and ditches, and type of farming, before the land was exposed.

It is remarkable that the salt was leached out of the sandy soils within one winter's rainy season, and out of the clay soils in from two to three rainy seasons, sufficiently to support the growth of plants.

The soil material of the sea bottom had been saturated with salt water for centuries; all air had been excluded. Analyses of soil water gave the same salt content as those of the sea water. One of the principal problems was to leach out the salt.

Rainwater had to be depended upon for this essential operation. The average rainfall on the area is about 700 mm, or 28 inches, of which 400 mm, or 16 inches, is evaporated, leaving about 12 inches to do the leaching. In the first stages much of this 12 inches flowed overland into drainage ditches causing erosion, but as the soil was voided of water, and vegetation covered the surface, percolation through the soil into the drainage ditches became effective. The rate of percolation of course depended upon the textural character of the material—slow in clays, and rapid in sands. Likewise, the clays contained up to four times the total amount of salt contained by the sand, requiring a greater total quantity of fresh water percolation for the removal of the salt.

Although rainfall is well distributed throughout the year the high evaporation rates of summer reduced effective percolation so much that the winter seasons (October to March) had to be depended on for the effective leaching out of the salts. When the surface layer of "soil" was leached to a depth of 8 inches, the chances for successful cropping were good even though the lower layers were still salty. The dry winter of 1931–32 retarded the rate of leaching. From the ex-

perience in the Wieringermeer Polder it can be said that, under normal winter rainfall of an annual 28 inches, clay lands will be desalted enough in 2 to 3 years to allow the sowing of grains with good chances of success; for sandy lands the period is much shorter, 1 or 2 years.

The structure of the soil material was studied in detail on the exposure of the secondary drains. A map was drawn up from these profile observations with remarkable detail. Old marsh subsoils, buried for many centuries, were of special interest. Geologically, the reclaimed polder, now 13 to 16 feet below sea level, was some 4,000 years ago at sea level. The land has been sinking at the rate of 1 mm per year. Buried marsh subsoils filled with decomposed roots and root channels of *Fragmitis communis* were examined in the field. Accumulations of yellow FeS occur in root channels. The pH of this material is 2 to 3. Heavy liming as well as aeration is required to make it productive of crop growth.

An interesting succession of volunteer vegetation came in on the area, of which salt bush and wild aster were the dominant species. Grains were first sown with partial success. But within 3 years the land is sufficiently supplied with lime, phosphates, potassium, and nitrogen, through fertilizers and green manure crops, to turn it over to the farmers for cultivation. The practice is to turn over to the farmers the land covered with a legume, either alfalfa or clover, or both.

The Government retains the ownership of the land and only leases it out for a period of 6 years to a selected applicant. The farming operations are entirely under Government control, until the farm is leased to the farmer. He is then given detailed advice in the management and cropping of this newborn land. He is not compelled to follow the advice, but because of the unusual problems confronting them, the farmers are quite ready to accept the advice of the technical experts. The successful handling of the farm will determine renewal of the lease. This past year there were 51 farms available, and for these more than 1,030 applications were received. Thus a very careful selection can be made.

Mr. de Jong, who is the land manager for the Wieringermeer Polder, was very courteous and willing to give us the details of their methods of handling land applicants and the farms. He holds a position not unlike that of Saint Peter, who determines who should be admitted to this new heaven on earth. The Dutch are planning to avoid on this newborn land the sins of the agriculture of the past.

We were interested in the contract with the farmers and secured copies of both the application and the contract. The Consul General of Amsterdam, at the request of the Legation Office, was good enough to translate these for us.

The Government builds the dykes, prepares the land, cropping it through the nursing stage, builds the houses and the barns, and is responsible for the entire drainage system. The Government furnishes technical advice for the farming of the new land; it does not require that the farmer follow the advice. He is put upon his own responsibility to run his farm under the broad terms of his lease contract with the Government.

The applicant, to be successful, must be of good character, and of good family; must have sufficient capital to equip the farm with machinery, to set up housekeeping, and to carry him through a period of possible crop failure. The source of his finances may not be a bank but relatives. The reason for this appears to be that relatives will be more lenient during hard times than a bank. It is not desired that banks gain a foothold in the control of the farmers' finances in this area.

Farms are laid out in different sizes—smaller in the sandy lands and larger in the clay lands. The sandy lands are suited best to all grass or dairy farms of one-family size with no hired labor required. The clay-land farms are suited to growing of grains, and are expected to require hired farm labor. Mixed farms are of an intermediate size. The areas vary from 50 to 65 acres for small dairy farms to 120 to 175 acres for the grain farms, where the farmer becomes essentially a manager.

Suffice it to say, that the principal crops are wheat, barley, rye, pasture, sugar beets, potatoes, cabbage, and other vegetables. We marvel at this magnificent achievement. It goes to show that newborn lands of suitable textural character and composition can be made to produce heavy crops regardless of the profile development. There are some far-reaching implications in this fact.

This vast undertaking, however, has been under consideration for a long time. The first serious thought of such a project was presented some 200 years ago. It was seriously considered nearly a century ago, and the plans which were finally followed were prepared by Lely some 30 years before they were actually put into effect by approval and an appropriation of the Dutch Parliament (1918). A period of a generation was given over to discussion and planning, before the project was finally approved and put into effect.

We had a number of conferences with some of the outstanding authorities in Holland, but unfortunately

there was no time to visit and consult with all of those whose names we had listed in our itinerary. Especially was I interested in our conference with Dr. van Iterson, president of the National Research Council, and director of the Organization of Applied Sciences. We had much in common in discussing the problems of how to make research responsive to practical farming and action programs in agriculture, and to make such practice and action programs responsive to the findings in research. Dr. van Iterson informed us of a law passed in 1930 to bring about such an objective, but thus far the stipulations of the law had not been put into practice. He is responsible for finding a way to apply the intent of the law, and confided in us that it is a difficult matter.

There is a tendency in Holland to make a sharp distinction between science and practice in agriculture. Laboratory scientists and the farmers are separated by a wide gap. Field men have not yet been given enough standing. Thus far, the laboratory scientists dominate agricultural science. I found some who deplore this domination of the laboratory analysts in agriculture in Holland. They speak very highly of our method in the United States of giving soil surveyors standing and of accepting their conclusions drawn from their field observations—and where laboratory analyses are used to supplement the interpretation of the field observations.

There was not time to visit the Koloniaal Institute in Amsterdam, as I had hoped to do. In fact, there were a number of things which we were unable to do on this part of our trip, which I hope may be done on the return, if at all possible.

Hydraulic Laboratory: We spent an interesting day at Delft, visiting Professor Muysken, of the University of Delft, who conducted us over the Hydraulic Laboratory. We shall have more to say of this in a separate memorandum to our research group We found this famous laboratory engaged in model experiments to find solutions of dealing with bed-load sands. A most interesting problem had been worked out in models. The problem was to keep a river channel clean where it crossed a canal; the river was one of the branches of the Rhine, and the canal one of the large canals so common throughout Holland. The solution consisted in constricting the river channel as it entered the canal, and as it left the canal; circular bays with a diameter twice the width of the canal were built on each side of the river channel so that the constriction wing walls coincided with the circumference of the bays. As the river current passed through the waters of the canal a portion of the current would be split off on the far restriction wing wall, and follow around the circumference of the bay and in its circular course impinge upon the river current as it passed through the canal waters. The eddy waters of the bays served as two water roller bearings on each side of the river channel. They served to restrict the width of the river current by the eddying water. The velocity of the river current was maintained and bed-load material was carried through the canal. This was one of the neatest solutions to a problem of this character that I have ever seen.

The people of Holland were very concerned a few years ago with the rate at which the three channels of the Rhine were filling up with sand washed down from the higher reaches of the stream. After a time the bed of the channel had been raised more than 4 meters; the dykes were becoming dangerously high. About this time demands for building sand increased. The sands of the Rhine were found suitable. Dredging of the sands began and the bottom of the river was gradually lowered 4 meters. And now the demand for sand is greater than the bed-load inflow from the upper reaches. Accordingly, a law has been enacted which fixed the extraction of sand from the river to an amount equal to the annual inflow.

Wageningen, the site of the agricultural college, is a most interesting place. We found evidences of serious wind erosion over an extensive area, covering, we were told, as much as 60,000 hectares, or more than 120,000 acres. These are the sandy lands above high tide level. It appears that man entered this area of eastern Holland soon after the recession of the ice sheet of the last glacial period, when the land was covered with tundra. Evidences were found to show that he depended on the reindeer as a stock animal. The forest cover invaded the area during man's occupation, so that civilization and forests have developed together in this area. We were shown by Dr. Edelman and Dr. Oosting, in pits dug especially for us in the field, evidences of formerly cultivated soils overwhelmed by sand, later covered with vegetation, cleared and cultivated, and again abandoned and overwhelmed by sand and recovered by vegetation. The fields of early man in this period were small. Apparently at some time or other the entire area had been worked over more than once.

It was the custom in early times to border fields with earthen walls on which oaks were planted to form oak hedges. These evidences open up a most fascinating chapter in land use, and we shall follow the work of the soils men and geologists at Wageningen with special interest. Practically nothing of their work has thus far been published, but will create great special interest.

BOOK REVIEWS AND ABSTRACTS

By Phoebe O'Neall Faris

BEHOLD OUR LAND. By Russell Lord. Boston, October 1938.

This is a background book, for people capable of thinking. It should be immediately commended to the schools so that teachers may read it and in one way or another use it in building up courses including sound conservation material. Mr. Lord's great story of "soil, air, water, and protoplasm—plant, animal, human—all part of the same going concern" is more than a book about the land. It gives us a new philosophy of earth use, of depressions and leadership and the "groping humility" of masses seeking comfort, of despoliation of the land and the "free spirit." Almost, it gives us the reason for the human race on earth, using lands and waters and minerals and animal and plant life—to say nothing of the air we breathe; some reason for the everlasting persistence of human genius and effort. Because of its wealth of authentic information, Behold Our Land will make remarkably fine supplementary reading for upper-grade and high schools, while teachers in lower grades will find what they have been looking for in the way of soil and water conservation material suitable for adaptation to nature study, geography, and history classroom studies and activities.

The best thing about Mr. Lord's book is its authenticity. Next best is its way of telling, for the style is vigorous and purposeful—the style of a writer who knows what he is writing about, who makes no guesses and whose vision pierces the curtains of *laissez-faire* and uncertainty. When Russell Lord reminds us that "our last farmland frontiers in Montana and elsewhere went to smash in the post-war collapse that hit far-western agriculture along with drought in the early 1920's" and that the depression which started in 1929 "was the first major depression we had to stand and face without new country 'back of yonder' to surge upon and possess," we are brought up with a jerk because we know that the statement is utterly true. We know that our surging and possessing days are over and that the immediate future must bring conservation, reconstruction and rehabilitation or else—What else but decadence? The United States, *decadent*. It is unthinkable. And because it is unthinkable, this book is strongly recommended for adaptation in the schools.

For good reason, Behold Our Land was chosen by the Scientific Book Club as the October scientific book of the month. As many of us know, it was at the request of the Chief of the Soil Conservation Service, Dr. H. H. Bennett, that Russell Lord began, 3 years ago, the gathering together and the sifting and sorting of accurate data and authentic information for the making of a publication which would tell the whole story and the true story about soil wastage in our country, its history, causes and effects, and the conservation practices now being pushed to repair the damage before it is too late. Much of the material is Soil Conservation Service material, gleaned from many projects. The photographic sections of the book show some of our finest pictures which tell their own story of soil healing.

As for the story itself—it reads like a novel, tells many a tale of the people as they surge back and forth across the land—it is absorbing and packed with pertinent information. There is a chapter on "elder lands" wherein we find sketches of ancient places and peoples, China, the Holy Land, and Egypt, Mediterranean countries rising to magnificence and falling upon harassed and subdued soil, Old Germany with her groves and tribal deities; and then the lost splendors of the Incas and the Mayas. All great and glorious for a time, but bungling in agriculture; all perished from the earth. This chapter on elder lands is excellent background, swiftly told and vigorous—the story of ancient man as a despoiler of land.

And then the New Land, our land, America, United States soil. Guided by Russell Lord we look at our country, *then* and *now*. We follow the western migrations and read the account of the gathering of "princely fruits" of the soil, of the harvest of wildlife and the death of the trees. Of "wounded grass" and encroaching desert, dust, maddened rivers. It would be depressing indeed were it not for one thing: As we go along we are shown soil- and water-conservation projects and demonstrations, grass laying the dust, young grass, young shrubs, and young trees clothing the wounded slopes, crops on the contour, gullies healed, havens for birds and animals—the Soil Conservation Service at work with many thousands of farmers who eagerly come to look and go home to do.

In Behold Our Land there is a map of our country that you can *feel*. This book advertises soil healing to the people who are responsible for that map—that country.

FOREST BIBLIOGRAPHY to 31st December 1933, Part III. University of Oxford, England. 1938.

An abstract of Parts I and II of this valuable bibliography appeared in the March 1938 issue of SOIL CONSERVATION, page 243. Part III, which has just arrived from England, contains about 3,500 references of forest-protection and related subjects. The material is organized under seven headings: (1) Man. Demarcation, offenses; (2) Animals, including bird and game preservation; (3) Atmospheric influences. Frost, isolation, wind, hail, snow, etc.; (4) Fire; (5) Weeds, including phanerogamous parasites, climbers, etc.; (6) Other agencies: Floods, swamps, shifting sands, avalanches, landslips, etc.; reclamation works, including protection afforestation; drainage; damage by chemical fumes; shelterbelts, shade trees, etc.; (7) Fencing, including hedges.

Section 6 should be consulted for references pertaining to soil erosion and its control.

AGROECOLOGY AS A BASIC SCIENCE OF SOIL CONSERVATION

(Continued from p. 141)

establishment of real typical hardy strains (agrochorotypes) for the region.

In any case the object of agroecology is to find proper methods for description and classification of regional ecological types of our agricultural plants. This classification should be of great value to agriculture; existing old-fashioned taxonomic classifications are altogether unsatisfactory and do not cover the great diversity of cultivated plants. Agroecological classification, moreover, should be based upon taxonomic classification as a starting point. We shall consider some ecological features comprising the ecotype, as modifications (continued modifications), which I indicate thus:

Caulomorphosae	for stem modifications.
Rhizomorphosae	for root modifications.
Clonomorphosae	for branch modifications.
Anthomorphosae	for flower modifications.
Carpomorphosae	for fruit modifications.

Only on the basis of close study of these features of chorotypes can we get material for comparative studies of regional types of crop plants. Comparison will show that the chorotypes are *isotypical*, *homotypical*, or *heterotypical* to each other. All regional types—agroecotypes or agrochorotypes—should be described on the basis of ecological *diagnosis*, similar to taxonomic diagnosis, but with more detailed description of all vegetative parts, reproductive characteristics, and yield.

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